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FOREST Pest LEAFLET

# Dwarf Mistletoes

L. Unger

Female (pistillate) flowers

## Introduction

Dwarf mistletoes, *Arceuthobium* spp. (Viscaciae), are widespread and destructive parasitic flowering plants that occur in the southern three-quarters of British Columbia. They are also found in parts of Africa, Asia, Europe, North and Central America, and the West Indies. They attack a wide variety of conifers, causing a loss of vigor, growth and quality, as well as tree mortality. Annual volume losses

Hemlock dwarf mistletoe: aerial shoots with berries. Note also swollen stem of host.

Large stem swelling on hemlock caused by hemlock dwarf mistletoe

Canada-British Columbia Partnership Agreement on Forest Resource Development: FRDA II

Canada

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Dwarf mistletoes and their hosts in British Columbia.

| Dwarf mistletoe | Occurrence | Principal hosts | Secondary hosts | Occasional or rare hosts | Useful resistant species |
|---|---|---|---|---|---|
| *Arceuthobium americanum* Lodgepole pine dwarf mistletoe | Interior | Lodgepole pine[1] | Ponderosa pine | White spruce<br>Engelmann spruce | Douglas-fir<br>Subalpine fir<br>Western larch |
| *Arceuthobium tsugense* subp. *tsugense* Hemlock dwarf mistletoe | Coast | Western hemlock | Amabilis fir | Sitka spruce<br>Grand fir<br>Mountain hemlock<br>Western white pine | Douglas-fir<br>Western red cedar |
| Shore pine race | Coast | Shore pine | - | Western white pine<br>Western hemlock | Douglas-fir |
| *A. tsugense* subp. *mertensianae* | Coast | Mountain hemlock<br>Amabilis fir | Alpine fir<br>Western white pine<br>White bark pine | Engelmann spruce | Douglas-fir<br>Shasta fir |
| *Arceuthobium laricis* Larch dwarf mistletoe | Southeastern interior | Western larch | Lodgepole pine<br>Subalpine larch | Ponderosa pine<br>Western white pine<br>Engelmann spruce<br>Subalpine fir | Douglas-fir<br>Western red cedar<br>Western hemlock |
| *Arceuthobium douglasii* Douglas-fir dwarf mistletoe | Extreme southern interior | Douglas-fir | | Grand fir<br>Engelmann spruce | Ponderosa pine<br>Western larch<br>Lodgepole pine |

[1] Jack pine is a principal host in other parts of North America

to dwarf mistletoes in British Columbia are estimated at over 3.7 million $m^3$. In addition to dwarf mistletoes, only one species of true mistletoe, *Viscum album L.* subsp album, has been recorded on deciduous trees in Victoria.

## Hosts and distribution

Five species of dwarf mistletoe occur in British Columbia. Each dwarf mistletoe does most of its damage on a principal host, but each also parasitizes secondary and occasional hosts.

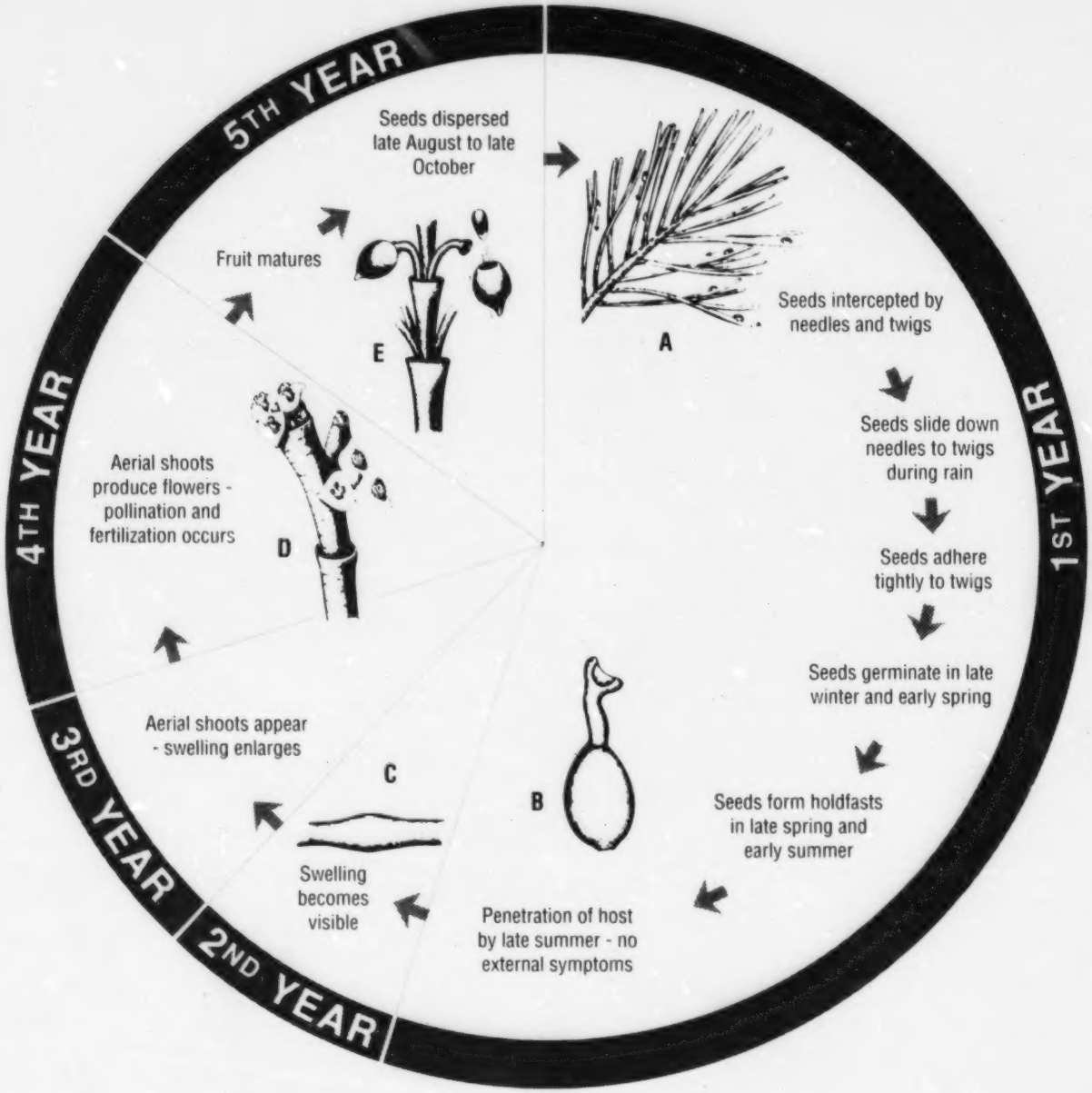
In British Columbia, lodgepole pine dwarf mistletoe extends from the summit of the Coast Range eastward to beyond the provincial boundary and from the international boundary northward to 57° north latitude.

Hemlock dwarf mistletoe exists as three segregates in forests on the seaward side of the Coast Range; one segregate primarily parasitizes western hemlock, another primarily shore pine, and a third primarily occurs on mountain hemlock and amabilis fir. Hemlock stands of the interior wet belt are free of dwarf mistletoe infection.

Larch dwarf mistletoe is restricted to southeastern British Columbia in the Osoyoos, Upper Arrow Lakes, Cranbrook triangle. It has not been found on eastern larch.

Stands infested by Douglas-fir dwarf mistletoe are found only in the Okanagan and Similkameen valleys and in the Creston area. Isolated infested stands occur near Lytton, Sicamous, and Rossland. Douglas-fir in coastal stands have been free of infection except for one verified sample found in Chilliwack in 1978.

Although recorded here, the distribution of western dwarf mistletoe, *Arceuthobium campylopodum*, is unknown in British Columbia. However, it occurs in natural ponderosa pine stands within 32 km of the international boundary near Kettle Falls, Washington.

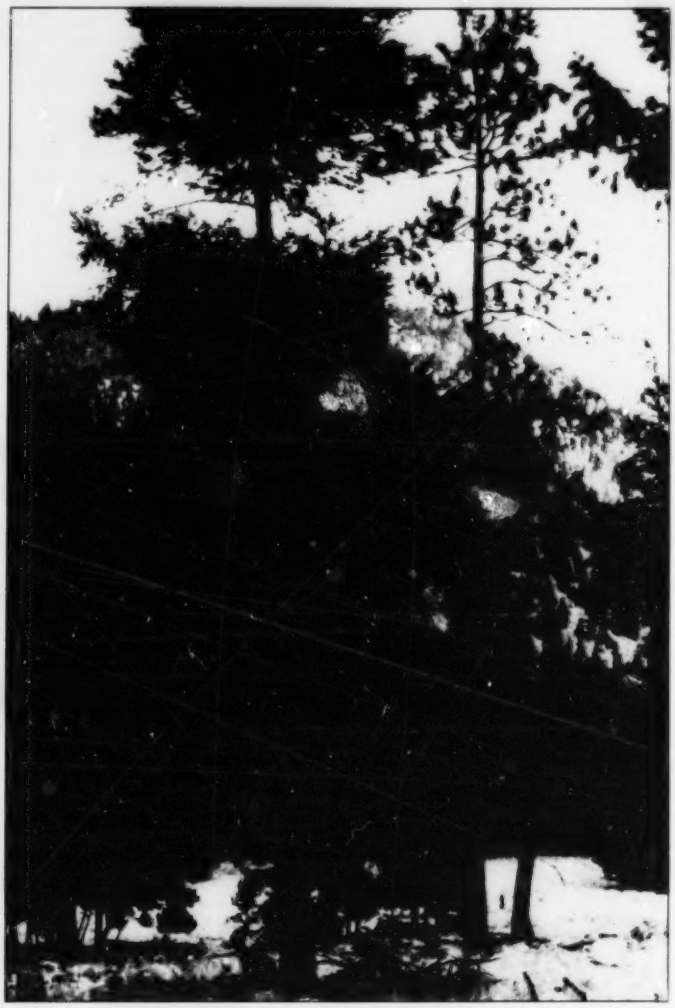

1ST YEAR
2ND YEAR
3RD YEAR
4TH YEAR
5TH YEAR
Seeds dispersed late August to late October
Fruit matures
E
Aerial shoots produce flowers - pollination and fertilization occurs
D
Aerial shoots appear - swelling enlarges
C
Swelling becomes visible
Penetration of host by late summer - no external symptoms
B
Seeds form holdfasts in late spring and early summer
Seeds germinate in late winter and early spring
Seeds adhere tightly to twigs
Seeds slide down needles to twigs during rain
Seeds intercepted by needles and twigs
A

Generalized life cycle of dwarf mistletoe:
A. Needle angles as they affect dwarf mistletoe seed movement.
B. A fully developed dwarf mistletoe seedling with holdfast.
C. Small branch swelling is the first indication of dwarf mistletoe infection.
D. Male (staminate) flowers of dwarf mistletoe.
E. Dwarf mistletoe seed discharge.

## Life cycle and habits

Dwarf mistletoes are perennial plants which depend upon living hosts for support, water, and most inorganic nutrients. Once established, they can survive as long as the host tissue remains alive.

The life cycle is initiated in the fall by the explosive discharge of the seed from the fruit. Seeds are covered with sticky viscin enabling them to adhere to foliage or less commonly to twigs and branches. During the first rain after dispersal the viscin cells absorb water, swell and become slippery, allowing seeds attached to needles to slide downward to the twig. Eventually, the seeds become tightly glued to the bark surface or sometimes to the foliage itself, and they overwinter in this condition.



Large witches' brooms on a Douglas-fir tree

Germination occurs as early as February for hemlock dwarf mistletoe and a few months later for species occurring in the interior of the province. Germination is indicated by the emergence from the seed of a reddish, root-like structure called a radicle. The radicle elongates until it reaches an obstruction such as a bark crack or the base of a needle, needle bundle, or bud. A holdfast is formed at this point.

Infection takes place through the action of a penetrating structure, followed by the extension of fine, finger-like filaments into the host bark (cortex). Young bark up to five years of age is most easily invaded, although older bark may be successfully penetrated on thin-barked hosts. By means of cortical strands, the dwarf mistletoe continues to grow longitudinally and circumferentially in the inner bark.

Growth directly toward the cambium is accomplished by means of structures called sinkers. As the branch grows in diameter, the sinkers are progressively embedded in the wood. By dissecting infections and determining the location of the deepest sinker, the year of infection can be established.

Dwarf mistletoe infection increases the number and size of host cells within the infected area, resulting in a swelling. This is usually the first external symptom of infection and is normally detectable in the second year following seed dispersal.

Aerial shoots do not usually emerge until the second or third year. Thus, detection of infection is difficult before three or four years of age. Male or female flowers are usually produced in the second year after emergence of the shoots. Male flowers have three or four petal-like parts which open, exposing the pollen sacs. Female flowers remain closed and relatively inconspicuous. Nectar produced by both types of flowers attracts insects which in turn pollinate the female flowers in spring on lodgepole pine and Douglas-fir, and in late summer on hemlock and larch. Wind also has a role in pollination, but it is not thought to be as important as insect pollination. The period from pollination to production of mature fruit is about 1.5 years.

Each fleshy berry contains a single seed which ripens within 14 to 18 months of pollination. As the fruit matures, an internal water pressure is built up until the fruit breaks away from its base, releasing the seed at a speed of about 80 km per hour. Seeds may travel distances up to 15 m (normally 6-11 m) from the source.

The rate of spread is greatest from infected overstory trees to understory trees. If distributed evenly, fewer than 20 infected trees per ha could cause infection of all intervening susceptible regeneration. The rate of subsequent spread through even-aged stands of fairly uniform height is slower, generally less than 0.6 m/year. Spread through open stands is about 1.5 times faster than through closed stands because of more vigorous dwarf mistletoe plants and longer seed flights.

Some important characteristics of the four most important dwarf mistltoe species in British Columbia

| Dwarf mistletoe | Types of infection | Aerial shoots | | Time of | |
|---|---|---|---|---|---|
| | | Branching | Average max height (cm) | Flowering | Seed dispersal |
| *A. americanum* (lodgepole pine) | Localized and systemic | Whorled | 6 - 10 | April - May | Late August and early September |
| *A. tsugense* (hemlock) | Localized | Fan-like | 8 - 12 | July - August | Late September and October |
| *A.laricis* (larch) | Localized | Fan-like | 4 - 6 | July - August | Early to mid-September |
| *A. douglasii* (Douglas-fir) | Localized and systemic | Fan-like | 2 -4 | March - May | Early September |

## Detection

The most conspicuous dwarf mistletoe symptom is a proliferation of distorted branches called "witches' broom." The pendulous brooms characteristic of dwarf mistletoe on lodgepole pine and Douglas-fir result from systemic infections in which the infection keeps pace with all the terminal buds of the new growth. With larch and hemlock dwarf mistletoe, infections remain localized throughout their life, and are restricted to the spindle-shaped swellings on branches and stems around which a proliferation of branches may develop as dormant buds are stimulated. Both symptoms require close examination to ensure that the cause is dwarf mistletoe.

Systemically caused brooms will usually have leafless, branched greenish-yellow aerial shoots throughout. On localized infections, shoots are produced only at the infection's advancing edge. Aerial shoots have a whorled pattern on lodgepole pine mistletoe, and are in a fan-shaped pattern in the other species in British Columbia. Shoots are less than 6 cm long in larch and Douglas-fir mistletoes, but they are up to 12 cm long in hemlock and lodgepole pine mistletoes. Basal cups on the bark will help to confirm dwarf mistletoe as the causal agent when no living aerial shoots are present.

Within young stands, infection centers will usually occur around larger and older (residual) infected trees. "Red flagging" caused by squirrel feeding on infected branches is common on lodgepole pine, western larch and Douglas-fir. In mature stands, severe brooming of dead, top-killed or dying trees is the most conspicuous indication of infection centers.

## Damage

Dwarf mistletoes attack their hosts in all age classes, causing mortality or loss of vigor, as well as reduced growth and wood quality. In addition to direct tree mortality or top kill, the dead tissue produced by dwarf mistletoes provides entry points for stain and decay fungi in a seriously weakened host. Growth of severely infected lodgepole pine and hemlock can be reduced up to 32% and 40%, respectively. Even greater losses are possible in infected western larch and Douglas-fir.

The wood produced in infected trees is of inferior quality because branch swelling and stem infections cause abnormal grain, resin impregnation, and spongy wood texture. In addition, branch proliferations and swellings result in an increase in the number and size of knots.

## Control

### *Silvicultural*

Of all agents causing disease in forest stands, dwarf mistletoes are the most amenable to silvicultural control because of several biological limitations, including slow spread, restriction to a limited number of hosts, and dependence on living trees for survival. Treatment for a particular case depends on stand composition and density, stand age, number of years to harvest, disease incidence and pattern, growth rate of the stand, and the length of time the stand has been infected. Simulation models of infected stands have been developed for western hemlock, for ponderosa pine, and for lodgepole pine to estimate the spread and intensification of the disease for a range of stands and infection conditions and sanitation procedures.

Reducing spread and intensification is possible if effective preventive measures are applied during or shortly after clear-cut logging. The first step is to prevent the establishment of the disease using the following techniques: (a) planning clear-cut borders along natural or

man-made barriers to mistletoe or in healthy stands; (b) avoiding partial cuttings in infested stands; (c) planning large clear-cuts to reduce the ratio of perimeter to area and hence the rate of re-invasion; (d) eliminating all infected residual trees and advanced regeneration during clear-cutting or shortly after; (e) planting a 20-m barrier strip in clearcuts along bordering infected stands using resistant species; and (f) using more seedlings of mistletoe-resistant species for replanting.

Aerial shoots of lodgepole pine dwarf mistletoe

Where preventive measures are not applied successfully, the disease can be reduced in young stands to a level at which there is little growth loss by keeping only uninfested and lightly infested trees in the stand. This can be done in conjunction with juvenile spacing. The highest priority for treatment should be given to infected hemlock stands up to 15 years of age and infected lodgepole pine, Douglas-fir, and western larch stands up to 25 years of age. All old infested residual trees in the sanitized area, and those along bordering stands, as well as young trees with stem infection should be cut. If practical, infected branches on young trees that do not have stem infections may be pruned. Sanitation in heavily infested stands older than 25 years is justified only if less than about 50% of the dominant trees are infested.

***Biological***

Among the 29 known fungal parasites of dwarf mistletoe, 18 canker fungi (which attack swellings) and four aerial plant parasites appear in Canada. Among the canker fungi, 17 are specific to *A. tsugense* and one is specific to *A. abietinum*; all occur exclusively in B.C. The three aerial plant hyperparasites most commonly encountered on all hosts in B.C. are *Wallrothiella arceuthobii*, which attacks seeds of female plants, and *Colletotrichum gloesporioides* and *Cylindrocarpon gillii*, which predominantly attack the shoots of the mistletoe plant. Several canker fungi, including *Nectria fuckeliana*, commonly girdle and kill mistletoe infected branches while having little impact on non-mistletoe infected tissue. However, attempts to increase infection through inoculation have been unsuccessful. While the possibility of utilizing fungal parasites as control agents is appealing, this technique has not yet been developed.

Dwarf mistletoes harbor considerable insect activity, but little is known about ecological relationships. The use of insects to control dwarf mistletoes has not yet been demonstrated.

***Chemical***

Chemical control of dwarf mistletoe has been investigated extensively, but no material has been found that warrants widespread application.

## Selected References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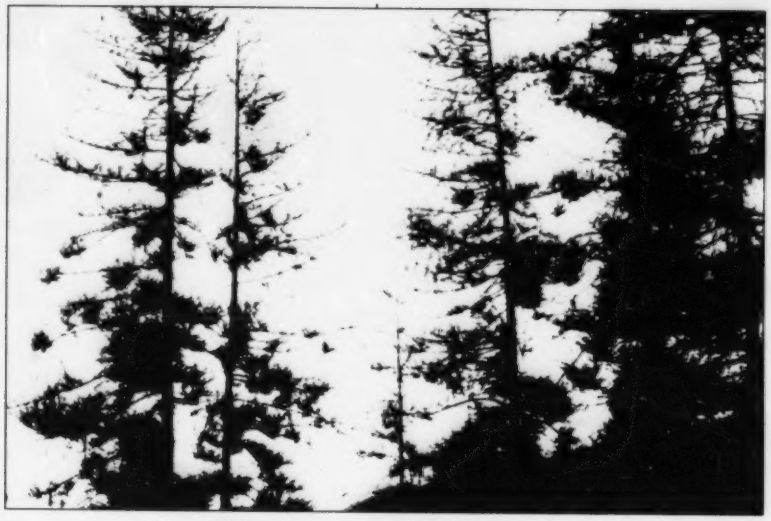
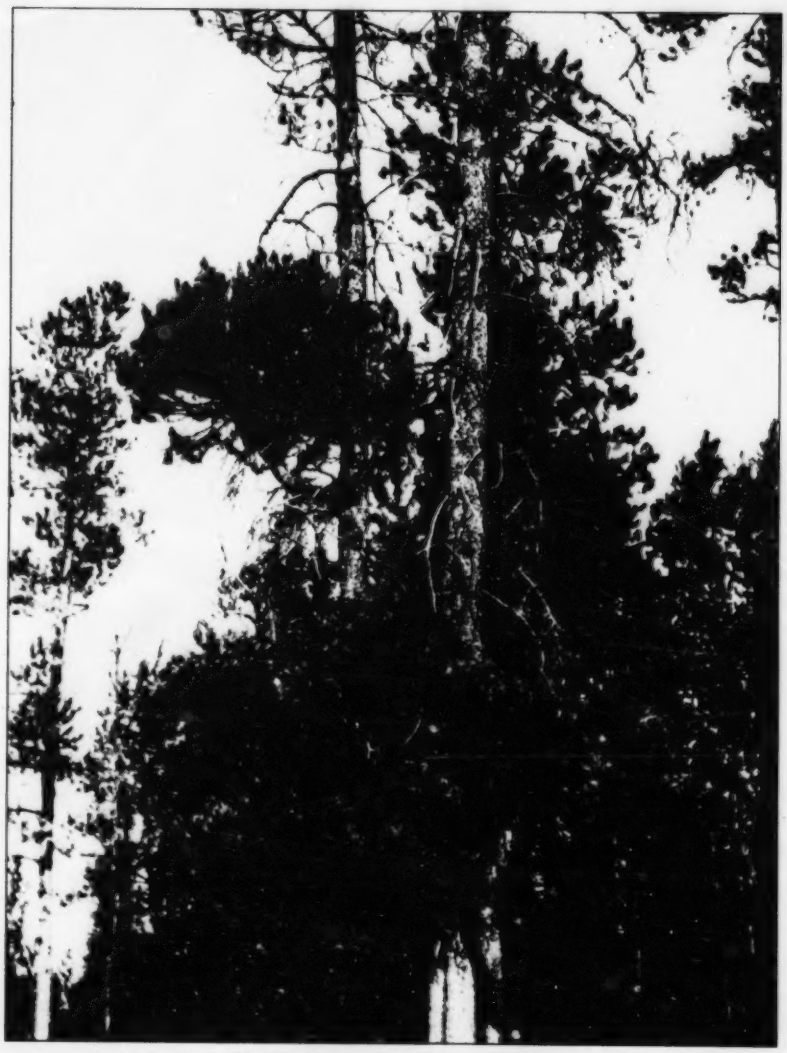


Witches' brooms on western larch trees



Witches' brooms on lodgepole pine

## Additional Information

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Pacific Forestry Centre
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Victoria, B.C. V8Z 1M5

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